

REPORT OF THE  
DEFENSE SCIENCE BOARD  
TASK FORCE  
ON  
**TRITIUM PRODUCTION TECHNOLOGY  
OPTIONS**



OFFICE OF THE UNDER SECRETARY OF DEFENSE  
FOR ACQUISITION & TECHNOLOGY  
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This report is a product of the Defense Science Board (DSB). The DSB is a Federal Advisory committee established to provide independent advice to the Secretary of Defense. Statements, opinions, conclusions, and recommendations in this report do not necessarily represent the official position of the Department of Defense.

This report is UNCLASSIFIED.



OFFICE OF THE SECRETARY OF DEFENSE

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WASHINGTON, DC 20301-3140

DEFENSE SCIENCE  
BOARD

MEMORANDUM FOR UNDER SECRETARY OF DEFENSE (ACQUISITION &  
TECHNOLOGY)

SUBJECT: Final Report of the Defense Science Board Task Force on  
Tritium Production Technology Options

I am forwarding the final report of the Defense Science  
Board Task Force on Tritium Production Technology Options.

This report examines options for tritium production  
capability that meets the tritium requirements for the nuclear  
weapon stockpile. The Terms of Reference directed that primary  
consideration be given to technical, legal, and economic risks,  
proliferation implications, and ability to produce the required  
amount of tritium when required.

The Task Force examined the dual track production  
technologies proposed in a 1995 Department of Energy Record of  
Decision and identified the implications associated with each  
option. The Secretary of Energy announced on December 22, 1998  
the selection of Commercial Light Water Reactors as the preferred  
facilities for producing a future supply of tritium.

I endorse the Task Force's findings and propose you review  
the Task Force Chairman's letter and report.

A handwritten signature in black ink, appearing to read "Craig Fields", is located above the printed name.

Craig Fields  
Chairman



ENSE SCIENCE  
BOARD

OFFICE OF THE SECRETARY OF DEFENSE  
3140 DEFENSE PENTAGON  
WASHINGTON, DC 20301-3140



January 29, 1999


MEMORANDUM FOR CHAIRMAN, DEFENSE SCIENCE BOARD

SUBJECT: Final Report of the Defense Science Board Task Force on  
Tritium Production Technology Options

Attached is the report of the Defense Science Board Task  
Force on Tritium Production Technology Options.

Congress directed the Secretary of Defense, in consultation  
with the Secretary of Energy, to establish a task force to  
examine tritium production technology options. The Task Force  
was to examine 1) The risk associated with the design,  
construction, operation, and cost of each option for tritium  
production under consideration. 2) The implications for nuclear  
weapon proliferation under consideration. 3) The extent to which  
each option contributes to the capability of the Government to  
reliably meet the national defense requirements of the United  
States. 4) Any other factors that the Secretary of Defense or  
Secretary of Energy considers appropriate.

My thanks to the members who responded to the urgent timing  
with intense focus. The Task Force especially thanks Captain Jim  
Lyons, USN from the Defense Science Board Office, Colonel Bill  
Smith, USAF and Colonel Mark Stevens, USAF for the special  
arrangements that made it possible to complete this task quickly  
and credibly.

  
Larry D. Welch  
General USAF (ret)  
Task Force Chairman

Attachment  
As stated



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## Introduction

The long-standing national security policy of the U.S. to maintain a robust nuclear deterrent continues to be supported by the Congress and the President. The President has stated that “. . . our nuclear deterrent posture is one of the most visible and important examples of how U.S. military capabilities can be used effectively to deter aggression and coercion. Nuclear weapons serve as a hedge against an uncertain future, a guarantee of our security commitments to allies, and a disincentive to those who would contemplate developing or otherwise acquiring their own nuclear weapons.”<sup>1</sup>

U.S. nuclear weapons designs require tritium, an isotope of hydrogen, which has not been produced in the U.S. since 1988, when the last tritium production facility (the K-Reactor at the Savannah River Site) was shut down. This long period without tritium production in the U.S. has been possible because arms control agreements reached in the early 1990s reduced the size of the U.S. nuclear weapons stockpile and because the Department of Energy (DOE) met stockpile tritium requirements by recycling the tritium removed from dismantled nuclear weapons. However, since tritium decays at a rate of 5.5% each year, a dependable source of tritium is required to continue to sustain the U.S. nuclear weapons stockpile to underwrite national security policy and to support arms control goals. The U.S. does maintain a five-year reserve supply of tritium, but this reserve is to be used only in an emergency. Current guidance states the reserve must be restored to its original level within five years of being used. To sustain the START I level, tritium production needs to begin around 2005 at a production capacity of about 3.0 kg/year. START II levels could be sustained with production of about 1.5 kg/year beginning around 2011.

## Background

The DOE examined several alternatives for the domestic production of tritium and in 1995, issued a Record of Decision (ROD) to pursue a dual-track approach to develop the two options it considered most promising. By the end of 1998, the Secretary of Energy is required by law to select one of these two options to serve as the primary source of tritium (the other alternative, if feasible, may be developed as a back-up tritium source).<sup>2</sup>

The DSB Task Force on Tritium was established in response to the FY99 National Defense Authorization Act, Title XXXI, Subtitle D (sec.3163). This legislation directed the Secretary of Defense, in consultation with the Secretary of Energy, “to establish a Task Force of the Defense Science Board to examine tritium production options.” Specifically, the Task Force was charged with examining:

- the risk associated with the design, construction, operation, and cost of each option for tritium production under consideration;
- the implications for nuclear weapons proliferation of each such option;

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1 A National Security Strategy for a New Century. The White House, October 1998.

2 The Defense Science Board (DSB) Task Force report was developed based on the information available during its December 1998 deliberations. Since the deliberations of the Task Force, Secretary of Energy Richardson, on December 22, 1998, announced the selection of the Tennessee Valley Authority’s (TVA) Watts Bar and Sequoyah commercial light water reactors (CLWR) as the preferred facilities for producing a future supply of tritium.

- the extent to which each such option contributes to the capability of the Government to reliably meet the national defense requirements of the United States; and
- any other factors that the Secretary of Defense or the Secretary of Energy considers appropriate.

A report is to be provided to the congressional defense committees not later than June 30, 1999.

The DSB Task Force on Tritium Production Technology Options was convened as a continuation of the DSB Task Force on Nuclear Deterrence (report dated October 1998). The Tritium Task Force membership is at Appendix A. In accordance with its congressional mandate, the Task Force focused its examination exclusively on the domestic tritium production alternatives and did not consider other non-production options such as potential foreign purchase. Furthermore, the Task Force did not directly address political considerations associated with the options and did not consider alternatives in the context of serving as a back-up source of tritium.

## **Tritium Production Technology Options - Overview**

### Irradiation Services

One of the dual tracks is to produce tritium by purchasing irradiation services using one or more commercial light water reactors (CLWRs). There are a large number of CLWRs available in the U.S. This track focused on one or more of the government-owned CLWRs operated by the Tennessee Valley Authority (TVA) or on the nearly completed government-owned, TVA-operated Bellefonte CLWR located at Hollywood, Alabama. Producing tritium in electricity-producing light water or gas-cooled reactors is the method currently used to produce tritium in the UK, France, and Russia and is the method used in the past in the U.S.

As a normal function of producing electricity, these reactors, with minor fuel adjustments, can irradiate rods from which tritium can be extracted without disrupting the reactors' function. To produce tritium, the boron-ceramic control rods normally inserted in the fuel bundles of pressurized water reactors are replaced with lithium aluminate ceramic rods, called Tritium-Producing Burnable Absorber Rods (TPBARs). The rods are bombarded by neutrons during the normal operation of the CLWR, which converts Lithium-6 to Lithium-7, which then transmutes into Helium-4 and tritium ( $H^3$ ).

The rods are replaced when the reactor is shut down for refueling after 18 months of operation. The tritium is recovered in the Tritium Extraction Facility (TEF), which is planned to be built at the Savannah River Site in South Carolina. With the current schedule, the first set of rods would be inserted in 2003, producing irradiated rods in 2005. However, the TEF is currently not programmed for operation until early FY 2006. Hence the TEF is on the critical path to meeting the tritium production need date to maintain a START I level stockpile of nuclear weapons. The "late-to-need" TEF operational date will require use of some part of the five-year reserve of tritium until the TEF becomes operational.

Commercial reactors currently owned by the U.S. Government and operated by the TVA include the Watts Bar Nuclear Plant Unit #1 in Tennessee, which is currently testing the TPBAR process using a Lead Test Assembly (LTA), and Sequoyah Nuclear Plant Units #1 and/or # 2. To maintain a START I stockpile level, two reactors are needed to stay below 2,000

TPBARs/reactor and thus not interfere with producing electricity. A START II stockpile level could be accommodated in one reactor.

Another option for irradiation services is to restart the Fast Flux Test Facility (FFTF) at the Hanford reservation in Washington State. This is a DOE-owned and operated facility. The restart would take approximately 3.5 years and could deliver irradiated rods around 2005. However, the FFTF could produce a maximum of 1.5 kg/year (1.0 kg/year at low risk) and requires either plutonium or highly enriched uranium (HEU) for fuel. Use of either fuel has important policy implications that are discussed later.

#### Accelerator Production of Tritium (APT)

The second of the dual track approaches is to develop a linear accelerator to produce tritium. This method produces a stream of protons bombarding tungsten to create neutrons that interact with Helium-3, producing Helium-4, which rapidly transmutes into tritium. While the underlying technologies are known and prototypes of several subsystems are being built and tested, the APT would be the first such system built to produce tritium on an industrial scale. The proposed DOE design would be located at the Savannah River Site in South Carolina and would operate for about 40 years. A "modular" design is being considered which would build the APT in two stages. The first stage would be capable of producing enough tritium to meet START II requirements. A second would provide production capacity to meet a START I stockpile level.

### **Summary Comparison of Technology Options**

The following chart summarizes a comparison of some key factors. More detailed explanations of each of these factors follows in the remainder of the report.

#### **Tritium Production Technology Options Summary Comparisons**

	<u>Irradiation Services</u>		<u>FFTF</u>	<u>APT</u>
	<u>Current CLWRs</u>	<u>Bellefonte</u>		
Delivery date	Early 2006	Early 2006	Mid-2006	Late-2008
Meet annual need	Yes	Yes	No <sup>1</sup>	Yes
Restore reserve	Yes	Yes	No	Variable <sup>2</sup>
Technical risk	LOW	LOW	Low	Moderate
Schedule risk <sup>3</sup>	Low	Moderate <sup>4</sup>	LOW	High
Investment(\$99M) <sup>5</sup>	579	1,866 - 2,446	800	3,116 - 3,631
Investment risk <sup>6</sup>	Low	Moderate	Moderate	High
Cost/gram ratio to APT <sup>7</sup>	.3 - .6 <sup>8</sup>	0 - .4 <sup>9</sup>	.5	1.0

1. Could meet START II level at moderate risk
2. No for START I level, Yes for START II level
3. All alternatives are subject to challenges from interest groups with attendant schedule risk
4. Regulatory - initial operating license required; Backup is interim production at another CLWR
5. Cost to complete including the Tritium Extraction Facility
6. Probability of over-investment given long-term need
7. Based on 40-year average
8. High end with current TVA proposal -- Low-end if based on incremental cost or market price
9. Payback for one Bellefonte proposal yields, in constant dollars, a net return to the U.S. Treasury

## **Operational Considerations**

### Need and Timing

To sustain a START I stockpile level, approximately 3.0 kg of tritium/year are needed, with deliveries beginning around 2005. About 1.5 kg/year would be needed to maintain a START II stockpile with deliveries beginning around 2011. Since the time and process for moving from a ratified START II agreement to eliminating the requirement for a hedge to return to START I levels are undetermined, however, the need date for tritium production for sustenance remains 2005.

The earliest the CLWR irradiation services options could produce tritium is mid-FY 2006 (based on the TEF schedule). The FY 1999 Defense Authorization Act prohibited physical construction during FY 1999 on the TEF. The earliest APT could deliver, even with an aggressive schedule, is late FY 2008. Hence, maintaining the START I stockpile will require use of part of the five-year tritium reserve. The guidance for that contingency is that the reserve must be restored within five years. The capacity of the CLWR options can meet the reserve restoration guidance at any contemplated stockpile level. The FFTF option cannot meet the reserve restoration guidance with reasonable risk even at the START II level. The APT option cannot meet the reserve restoration guidance at the START I level.

### Flexibility and Investment Risk

Considering the wide range of uncertainties about progress in arms control and resulting uncertainties about the size of the stockpile, the Task Force examined the flexibility of each option. It is desirable for the option to be scaleable to START I or START II (or START III), at least through the early part of an option's life span, until the future is more predictable. While the Task Force did not examine this in great detail, START I is assumed to be the maximum level for tritium production, although this will not necessarily always be the case. Irradiation services at one or more CLWRs could produce varying amounts of tritium (up to more than 3.0 kg/year) as needed while still performing their design function of producing electrical power. The large up-front investment required to complete the Bellefonte reactor subjects the DOE to rate-of-return on investment risk since production at lower rates would not give good return on the DOE investment. However, the facility would still be performing its design function of furnishing electrical power. The FFTF is capable of producing only up to 1.5 kg/year at reasonable risk. The APT could be sized to produce 1.5 - 3.0 kg/year, but any future excess capacity represents a large and irrecoverable investment since the primary purpose of the facility would be to produce tritium.

### Sustainability and Backup

The Task Force also considered long-term availability of tritium in the face of plausible future developments. For irradiation services using CLWRs, given the number of such reactors in the U.S. (over 70) and the initial favorable results of the almost completed test program, the risk of technical failure is very small. Hence, the principal risks to sustainability come from regulatory, policy, or possible interest group opposition issues. These are discussed later in the report. The backup for a technical failure in a reactor can simply be to shift production to another properly licensed reactor. The technology option backup for a newly emerging regulatory or policy issue with use of reactors to produce tritium would be an APT option held in a five-years-

to-deploy state of development. For the APT, the backup plan is to build the TEF, complete the licensing process for a CLWR and to fabricate and store two sets of TPBARs (a three year supply).

### Safety

The Task Force met with representatives from the Defense Nuclear Facilities Safety Board (DNFSB) and discussed safety issues for the various options but did not meet with the Nuclear Regulatory Commission (NRC). Given the safety steps underway and the NRC-granted license for the Lead Test Assembly, now underway at Watts Bar, the Task Force did not foresee risks in this area. For the CLWR, the DNFSB was reviewing the TEF design. Similarly, the DNFSB is engaged as external design and safety reviewer for the APT and discussed environmental, health and safety concerns, which apply to construction and operations of the APT. The DNFSB also stated that either option could be safely constructed and operated.

### **Task Force Findings - Operational Considerations**

- The need for tritium is clearly defined and documented in support of national security policies.
- All the production technology options are late-to-need to maintain the stockpile at the START I level with the required tritium reserve.
- The CLWR proposals can meet the need by dipping into the tritium reserve with the capacity to restore the reserve within current guidelines.
- The APT proposal can meet the need by dipping into the tritium reserve but will take longer than the current guidelines to restore the reserve.

### **Cost**

The Task Force reviewed the current cost estimates and pricing arrangements for all options available at the time of the Task Force's deliberations. The following chart portrays the estimates of investment costs and investment profiles for the various options. The chart is in constant FY99 dollars. While present value could be more revealing, there was not sufficient detail available on all the options to provide a credible present value calculation. In any case, the constant dollar portrayal provides useful information. The cost to complete includes the cost of the TEF for all options since it is required to support the backup CLWR option even with the APT approach.

## Cost and Funding Profiles (\$FY99)

<u>Option</u>	<u>Cost to Comp</u>	<u>Annual</u>	<u>Investment Profile<sup>6</sup></u>							
			<u>99</u>	<u>00</u>	<u>01</u>	<u>02</u>	<u>03</u>	<u>04</u>	<u>05</u>	<u>06</u>
Existing CLWR <sup>1</sup>	579	135	91	135	113	84	64	88	84	60
Bellefonte A <sup>1</sup>	2,446	34 <sup>2</sup>	191	1,013	1,000	90	62	(15)	(17)	(47)
Bellefonte B	1,866	34	62	99	140	300	285	273	263	228
Bellefonte C	1,871	34 <sup>3</sup>	62	290	316	300	285	264	254	42
FFTF	800	100	57	96	157	167	210	168	149	127
APT 1.5 kg/yr <sup>4</sup>	3,116 <sup>5</sup>	100	137	185	191	314	346	347	360	346
APT 3.0 kg/yr	3,631 <sup>5</sup>	140	149	299	528	701	762	692	292	189
APT Backup	445		105	98	68	61	56	57		

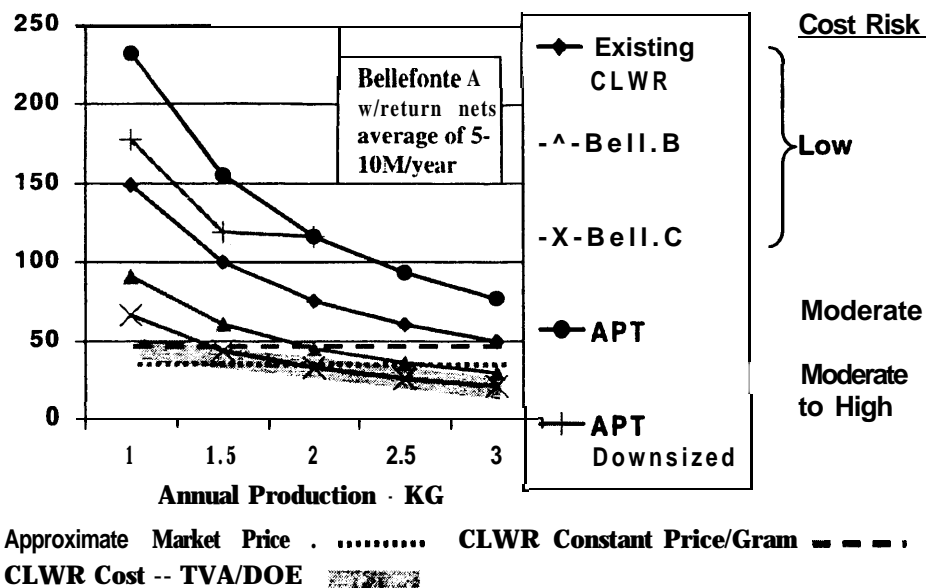
1. Profile predates congressional prohibition on TEF construction in FY99
2. Return to treasury over 40 years: \$4.4B
3. Return to treasury over 40 years: ~\$1B
4. Decision required by 2001, TEF IOC 2011 (investment begins in FY04)
5. Prior costs: \$385 million
6. Includes estimate of TEF program costs

TVA proposed three different pricing arrangements for completing and operating Bellefonte. The original proposal, labeled Bellefonte A on the chart, has large up-front costs but returns \$4.4 billion to the treasury over the life of the program for a net return in constant dollars. Bellefonte B reduces the investment cost but provides no return. Bellefonte C increases the front-end cost over Bellefonte B and returns approximately \$1 billion to the U.S. Treasury.

The Task Force noted that most of the investment costs portrayed above are not in the current DOE budget. Further, the FY 1999 Defense Authorization Act prohibits physical construction during FY 1999 on the Tritium Extraction Facility. The TEF is now on the critical path for producing tritium in a reactor and is an essential part of the backup plan for the APT option.

To compare life-cycle costs of the various options, the cost/gram for a fixed period for various levels of production is useful. The next chart provides that comparison.

## Approximate Cost per Gram (FY99 \$000) 40 Year Average



Combining insights from both charts, the two options requiring the largest up-front investment are the APT and completing the Bellefonte CLWR. The largest life cycle cost, regardless of level of production, is associated with the APT option. Using the price figures from current TVA proposals, the lowest life cycle options are those which complete the Bellefonte CLWR since the proposal is to provide 25 years of tritium production with no further payments to TVA. Hence, the only operating costs associated with these proposals are for the TPBARs, operation of the TEF, and transportation and DOE support costs (a total of \$34 million/year).

The TVA proposal for irradiation services using existing TVA-operated CLWRs briefed to the Task Force calls for a constant cost/year for 25 years regardless of the quantity of tritium produced, hence the higher cost/gram as quantities are reduced. The level dashed line shows the comparison for a constant price/gram with the current proposal. The shaded area shows a range of estimates of the TVA costs based on Congressional Budget Office (CBO) estimates. Hence, if the cost/gram for use of existing CLWRs is based on cost to TVA, it would become the lowest life cycle cost proposal as well as the lowest investment cost option.<sup>3</sup> The Task Force noted that

<sup>3</sup> Under the terms of the Economy Act, services provided among different agencies of the government are provided at actual cost. In April, 1999, DOE published its Tritium Record of Decision using the most recent cost figures for the CLWR and APT for both START I and II scenarios. The April 1999 CLWR figures, now in line with the Economy Act, closely agree with the CBO estimates. For example, START I CLWR irradiation costs range between \$8.8 and \$16.0 million per kilogram, and START II from \$11.3 to \$20.5 million. These figures confirm the Task Force's observation that the CLWR option has the lowest life-cycle and investment costs using the CBO estimates, under the terms of the Economy Act.

current price of tritium purchased commercially is approximately \$30,000/gram for quantity purchases.

### **Task Force Findings - Cost**

- APT requires the highest front-end investment and delivers tritium at the highest cost/gram life cycle cost.
- Although irradiation services using an existing CLWR requires the lowest investment cost, with TVA proposals provided to the Task Force, it operates at a high cost/gram compared to operating a Bellefonte reactor or compared to the current market price of tritium.
  - Existing proposals for CLWR use are constant cost/year for 25 years regardless of tritium production rates.
  - Constant cost/year drives up the cost for operating at less than maximum capacity to multiples of the market price.
  - TVA incremental cost is well below market price.
- A proposal for CLWR operation based on incremental cost to TVA or market price would provide for the lowest investment and operating cost/gram.
- Completing and operating a Bellefonte reactor requires a large up-front investment but provides a low life cycle cost/gram.
- Confidence in APT development and construction costs is tempered by the preliminary design being only 30 - 35 % complete and by lack of a complete system test until the entire accelerator and separation systems are operating at scale.

### **Technical, Schedule and Regulatory Risks**

#### **CLWR**

The Task Force found minimal technical risks associated with the CLWR options. There is no change to proven reactor operations. Lithium is used to produce tritium in the United Kingdom, France, and Russia, and is the method previously used in the United States. The design of the TPBARs is fully developed, evolving from a 1960's design. A request for proposal is to be issued in FY 1999 for long-term, production-scale manufacturing services. Thirty-two TPBARs are being demonstrated as the Lead Test Assembly at the Watts Bar reactor to demonstrate that all aspects (from design to actual insertion in a reactor, through completed irradiation, transportation, and post-irradiation examination) are safe and technically straightforward. The TPBARs for the LTA were fabricated by Pacific Northwest National Laboratory with NRC oversight. To date, the monitoring process indicates that the TPBARs are performing as intended. This LTA demonstration is scheduled for completion in February, 1999.

The Nuclear Regulator Commission (NRC) has approved TPBAR design for use in a reactor, and Watts Bar was granted an amendment to its operating license to permit the irradiation demonstration. For full-scale operation, NRC approval of amended operating licenses is required for Watts Bar and Sequoyah. The NRC is reviewing the Production Topical Report on the use of TPBARs in production-scale quantities, and completion of this review is expected in March, 1999. Bellefonte requires a new operating license, but the construction license has been granted. The TVA bears the regulatory risk with Bellefonte, because it has offered interim irradiation services at no additional cost using existing TVA reactors if Bellefonte were delayed.

A draft environmental impact statement (EIS) has been published for Production of Tritium in a CLWR. The draft EIS projects no measurable health effects and states that incremental radiological impacts would be small. The final EIS and records of decision are to follow the Secretary of Energy's tritium selection decision. The Task Force believes that any potential regulatory risks to the CLWR options could be closed early in the program.

### **FFTF**

The Task Force found minimal technical risks associated with the FFTF, as it was designed for irradiation services and no new technology is required to fabricate FFTF fuel. However, the facility is not currently operational and is maintained in a stand-by condition. The staff is still in place, but the reactor is defueled, with sodium circulating, keeping it in a surveillance and maintenance status. The facility could be restarted in 3.5 years from a decision. There is high confidence that 1.0 kg/year of tritium could be produced in the FFTF, but only moderate confidence in 1.5 kg/year. Producing at the rate required to support the START I level is not feasible.

An EIS is required for the facility. The Task Force feels that regulatory risks for FFTF could be closed early in the program.

### **APT**

Technical risks with the APT are driven by the first-time integration of an accelerator and tritium production system at an industrial level. However, the Task Force found no technical "show-stoppers" at this time. Some critical laboratory demonstrations have been completed and additional demonstrations are scheduled in the next year. Engineering design began in early FY 1998, and preliminary design is 30-35% completed. However, technical risks will not be closed until late in the program because (1) the final design is not planned until the end of FY 2004 and (2) operational testing is to begin in mid-FY 2003 and be completed by the end of FY 2008.

The APT requires a non-nuclear facility-operating permit approved by the DNFSB. The plan is to complete the site-specific EIS and issue a ROD in the 2nd Quarter FY 1999. The Task Force did not see the APT regulatory process as a major risk area.

### **TEF**

The Tritium Extraction Facility will be built irrespective of which tritium production option is chosen. The extraction technology has been proven in a laboratory, and preliminary design has been completed. A draft EIS for Construction and Operation of TEF has been completed. Site preparation will not be completed until next year due to the congressional impact on the schedule (delays IOC to 2<sup>nd</sup> Qtr FY 2006). This delay makes the TEF a critical path, and the TEF is now late-to-need to meet the START I level requirement.

### **Task Force Findings - Technical, Schedule, and Regulatory Risks**

- Technical risks for any of the CLWR approaches and for the FFTF are minimal.
- Regulatory risks associated with the existing CLWRs can be resolved early in the program.

- Regulatory risk for the initial operating license for Bellefonte is mitigated by use of an existing CLWR for interim production. Actions are underway to license full production at Watts Bar.

For APT, the Task Force identified no show-stoppers.

Technical risks remain moderate and would be fully resolved late in the program.

Schedule risk remains high.

## **Proliferation, Policy, Interest Group Issues**

While the operation, cost, and technical issues associated with each of the options are less than fully resolved, the most controversial aspect of tritium production has been its perceived impact on U.S. nonproliferation policy. Some people have stated (1) that using a CLWR to produce tritium would violate a long-standing U.S. practice regarding the separation between civil and military nuclear facilities or (2) that producing tritium in a CLWR would violate U.S. laws prohibiting the use of special nuclear material (SNM) derived from commercial reactors for nuclear weapons.<sup>4</sup> It has also been asserted that the production of tritium in a CLWR or the FFTF would not be in keeping with the Non-Proliferation Treaty (NPT) and/or would violate International Atomic Energy Agency (IAEA) safeguards. Critics of the APT argue that it carries a large nuclear “footprint” -- that a large investment in a facility intended to sustain the U.S. nuclear stockpile would undermine U.S. nonproliferation goals by creating a perception that the U.S. is committed to long-term sustainment of the START I or START II level stockpile. Others have stated that producing tritium would encourage potential proliferators to establish their own tritium production facilities.

However, tritium is not defined as a SNM under the Atomic Energy Act of 1954, and producing tritium in a CLWR does not violate U.S. laws. In addition, the sites under consideration are owned by the U.S. Government and operated by the TVA. Hence, their use in the production of tritium would be comparable to past U.S. practice of government-owned nuclear facilities being used for both military and civilian purposes. For example, DOE’s N-Reactor was deliberately designed to produce plutonium for nuclear weapons while generating steam used in the commercial production of electricity. The Congress authorized construction and operation of electrical generating and transmission facilities using steam from the N-Reactor.<sup>5</sup> This practice of a dual military/civilian use facility is also seen in DOE’s K-Reactor, which produced plutonium for NASA, and in defense facilities, which provided radioisotopes for civilian applications. Additionally, this dual-purpose practice is embodied in the TVA’s long history of providing electric power for the production of enriched uranium used in U.S. nuclear weapons. It is significant to note that TVA was specifically chartered to serve both civilian and national security needs.

Also, tritium production does not violate the NPT. The U.S. is a nuclear weapon state party to the NPT and is not prohibited from producing nuclear weapons or the materials needed for their production. Further, while the U.S. has voluntarily placed its commercial nuclear

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<sup>4</sup> The 1983 Hart-Simpson Amendment to the Atomic Energy Act expressly prohibits the use of SNM derived from commercial reactors for nuclear arms.

<sup>5</sup> Public Law 87-701, 26 September 1962

facilities under International Atomic Energy Agency (IAEA) safeguards, these safeguards apply only to materials directly usable for nuclear weapons (e.g., plutonium or HEU) or materials that can be transformed into direct-use materials (e.g., low-enriched or purified natural uranium). The IAEA does not apply safeguards to tritium, which is considered a byproduct material, and has stated it “does not see a legal impediment to the possible U.S. production of tritium in a facility that is eligible for IAEA safeguards.”<sup>6</sup>

These facts have led a U.S. Government Interagency Review to conclude that “the nonproliferation policy issues associated with the use of a commercial light water reactor are manageable and that the Department should continue to pursue the CLWR option as a viable source for future tritium production.”<sup>7</sup>

Although the FFTF is currently subject to IAEA safeguards, the U.S. could reclassify it as a defense facility to remove it from IAEA inspection eligibility if it so desired. However, as explained above, the production of tritium does not violate IAEA safeguards. A more serious issue is that the FFTF must be fueled with plutonium or highly enriched uranium. If the FFTF were to be fueled with plutonium, it would soon (after about 18 months) become necessary to use plutonium the U.S. has declared excess to defense needs and which the President stated in March 1995 would “never be used to build a nuclear weapon.” The thrust of Secretary Pena’s address to the IAEA General Conference in September 1997 was that 52 tons of HEU and plutonium he was making eligible for IAEA inspections had been “removed from military use”.<sup>8</sup> While the U.S. has enough ‘unencumbered’ HEU (stocks not declared excess to defense needs) to fuel the FFTF, doing so could undermine the current U.S. policy of discouraging the use of HEU fuel globally.

There are no such concerns with the APT. The APT is to be a DOE-owned and operated facility intended primarily for defense purposes. While perceptions may persist that the APT represents a commitment to maintain large U.S. nuclear stockpiles indefinitely, there are also numerous proposals for dual-use activities for the APT. In any event, further arms reductions are dependent upon the U.S. having high confidence in the reliability of its smaller stockpile of nuclear weapons. The claim that the APT, or any other option, for that matter, will encourage proliferation has little basis -- proliferators do not need tritium for likely unsophisticated nuclear weapons designs. The Interagency Review concluded that the APT would raise “no significant nonproliferation policy issues” as long as adequate export control measures were maintained.<sup>9</sup>

The DSB Task Force agrees with the Interagency Review that nonproliferation policy issues are manageable for the CLWR options and are not an issue for the APT. Still, the specific means for production of tritium will remain controversial whichever alternative is selected. Those who advocate unilateral reductions in the U.S. nuclear stockpile will object to and challenge any production of tritium. Those who have an interest in a specific option may well

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<sup>6</sup> Interagency Review of the Nonproliferation Implications of Alternative Tritium Production Technologies Under Consideration by the Department of Energy: A Report to the Congress. Department of Energy, July 1998.

<sup>7</sup> *Ibid.*

<sup>8</sup> *Ibid.*

<sup>9</sup> *Ibid.*

claim proliferation concerns to support their preferred alternative. However, so long as the U.S. possesses nuclear weapons, it must have a reliable source of tritium.

### **Task Force Findings - Proliferation Policy and Intere Group Issues**

- The Task Force heard concerns, related to use of CLWRs, about variance to the practice of separating civil and military nuclear activities.
- The Task Force heard concerns, related to APT, that the large investment in a facility whose primary purpose is producing tritium gives the perception of long term commitment to the current (or START II) stockpile.
- The Interagency Review found:
  - For CLWR, policy issues are manageable.
  - For APT, no significant policy issues.
  - For FFTF, significant policy issues with the use of plutonium fuel declared excess to defense needs or use of highly enriched uranium fuel.
- The Task Force agrees with the Interagency Review findings.

### **Summary of Task Force Findings**

#### **Irradiation services using Commercial Light Water Reactors (Watts Bar or Sequoyah in Tennessee or Bellefonte in Alabama)**

- Earliest delivery of tritium to the stockpile is 2006 with the pacing item being the operational date for the Tritium Extraction Facility at the Savannah River Site in South Carolina.
  - Maintaining START I levels would require using up to 20% of the tritium reserve of five years. The proposed tritium production capacity could restore the reserve well within the current guidelines of five years.
- Producing tritium in a CLWR at the proposed levels does not significantly impact the cost or quantity of electrical power production. The additional costs associated with tritium production are to be borne by DOE.
- There is minimal technical risk.
- Regulatory and policy risks relating to proliferation concerns are manageable. The regulatory risk can be closed early in the program.
- There is continuing risk of impacts of opposition by various interest groups - government and non-government. An example could be continuing efforts to pass legislation that would declare tritium a special nuclear material and prohibiting its production for defense uses in commercial reactors.
- With current TVA proposals, completing Bellefonte to provide irradiation services entails a high front-end investment cost but provides for the lowest life cycle cost/gram of tritium. It also provides a valuable asset for a government corporation which otherwise might not be completed.
- With a proposal based on market price of tritium or the incremental costs of production, irradiation services using existing CLWRs provides for the lowest investment cost and life cycle costs competitive with operation of Bellefonte.

#### **Accelerator Production of Tritium at the Savannah River Site in South Carolina**

- The earliest delivery date of tritium to the stockpile is late in 2008.

- Maintaining START I levels would require using about three years of the five-year reserve. The proposed production capacity could not meet the guidance of restoring the reserve within five years.
- The large front-end investment to support currently anticipated stockpile levels creates a high risk of over-investment in a primary purpose capacity not needed for the long term.
- The system is at 30-35% preliminary design with key engineering development, demonstration, and testing well in the future.
  - At present the technical risk is moderate, but the system technical risks would only be closed late in the program.
  - The schedule risk remains high.
- The APT option requires the highest investment of all technology options and produces tritium at the highest life cycle cost/gram.

#### Irradiation Services from Restarting the Fast Flux Test Facility in Washington State

- The earliest delivery date of tritium to the stockpile is mid-2006, paced by operation of the TEF.
- Maximum production capacity at moderate risk is 1.5 kg/year. At low risk, the capacity is 1.0 kg/year.
  - The FFTF cannot meet the START I requirement.
- There are significant policy issues with proliferation implications:
  - The reactor uses plutonium or highly enriched uranium.
  - There is only an 18-month supply of unencumbered plutonium fuel available (one irradiation cycle).
  - Use of plutonium declared excess to defense needs or use of highly enriched uranium is at variance with widely stated U.S. policy and/or bilateral agreements.
- The investment costs are relatively low and the life cycle cost/gram moderately high.

## **Appendix A: Task Force Membership**

### Task Force Members

Jeffrey Cooper  
John Foster  
Sydell Gold  
Ronald Lehman  
George Miller  
Michael Pillsbury  
Paul Robinson  
James Schlesinger  
Richard Wagner  
Larry Welch, Chairman

### Executive Secretaries

Col William Smith, USAF  
Col Mark Stephens, USAF

### DSB Representative

CAPT James Lyons, USN